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DOUGLAS-FIR CONE AND SEED INSECT RESEARCH

Progress Report, 1957-1958

By

Thomas W. Koerber, Entomologist

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PACIFIC SOUTHWEST FOREST AND RANGE EXPERIMENT STATION

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U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE
PACIFIC SOUTHWEST FOREST AND RANGE EXPERIMENT STATION
Division of Forest Insect Research

DOUGLAS-FIR CONE AND SEED INSECT RESEARCH

Progress Report, 1957-1958

By

Thomas W. Koerber, Entomologist

SUMMARY

This is a report of the preliminary research work on Douglas-fir cone and seed insects, line project FS-2-e4-7. The principal objectives of this work are to determine the species of insects attacking Douglas-fir cones in California, the type and extent of damage done by each species, and when and how the damage is done.

As is sometimes the case with preliminary work, the results were somewhat less successful than expected because of unforeseen difficulties. Most notable among these were the high early mortality of cones and faster and earlier development of the insect than had been expected. In spite of these difficulties, a certain amount of reasonably reliable data were obtained to serve as a guide for future work.

The kinds and numbers of insects obtained from the infested cones under rearing conditions in the laboratory and in the outdoor insectary at Berkeley failed to reflect the composition of the insect population in the cones as determined by dissections. When cold treatments in combination with wet and dry conditions were used to attempt to break the winter diapause of the insects and to improve rearing results, the experiments were uniformly unsuccessful. It was concluded that some climatic conditions which do not occur in Berkeley are necessary for successful rearing of Douglas-fir cone and seed insects.

A series of experiments were conducted to determine the time and rate of attack of cone and seed insects and the amount and type of damage done at various infestation intensities. In these experiments, cone-bearing Douglas-fir branches were covered with fine mesh screening to exclude insects. The amount of damage and the species of insects which subsequently developed were compared in covered and uncovered cones from the same trees. Differences were assumed to be caused by the additional infestation of the unprotected cones after

the time the others were covered. Cone samples were examined in the course of the summer to gather data on the rate of development and mortality of the insects.

Heavy cone mortality early in the season reduced the size of samples, and high levels of insect damage seriously impaired the reliability of associating types and degrees of damage with certain insects. It is evident however that at least two species of insects, Barbara colfaxiana (Kearf.) and Contarinia sp., attack the cones as soon as the buds open. All of the insects develop rapidly so that much of the damage to the cones is done before mid-July. Two species of parasites, Apanteles petrovae Wally and an undetermined larvaevorid fly were found which attack the larvae of B. colfaxiana early enough in the spring so that adult parasites are produced before the end of July. The parasites were not abundant enough to produce high mortality of the host larvae.

Relatively small numbers of larvae of Barbara colfaxiana can greatly reduce the seed yield from Douglas-fir cones. The damage done by this species in the cone samples examined was so extensive that the damage done by the other species was frequently so obscured that it could not be estimated.

The most important conclusion from the data obtained in these experiments is that research on Douglas-fir cone and seed insects in northern California should be started by the beginning of April. Intensive observations should be carried out from early April until the end of May.

INTRODUCTION

Research on insects attacking cones and seeds of Douglas-fir was started in July of 1957 in the Orleans area of the Six Rivers National Forest.

Interest in this subject developed as a result of regeneration studies started by D. F. Roy 1/ in 1952. The studies of Roy indicated that since 1946, when logging activity in northwestern California increased sharply, regeneration of many of the cut areas was unsatisfactory. The study further pointed out that because of rapidly developing competition from brush and herbaceous plants, reproduction must become established on a clear cut area within three years after logging in order to successfully regenerate the stand. Insects were mentioned as a prominent factor reducing the supply of seed available for regeneration.

1/ U. S. Forest Service. Annual report 1957, Calif. Forest and Range Expt. Sta. 82 pp. illus.

Investigations of insects destructive to cones and seeds in California, as well as many other parts of the West, were started in 1912 2/ and continued for a period of 5 years. After a lapse of 37 years in which very little work on cone and seed insects was done, surveys of cone and seed insect damage were begun in 1954 and continued for a period of 5 years. 3/ These studies indicate that insects regularly destroy a large part of the Douglas-fir seed crop.

The objectives of the present research was to provide preliminary data which, along with the work of other researchers, would serve as the basis for an analysis of the problem of insect destruction of the Douglas-fir seed crop in California.

Most of the field work on this project was done in the vicinity of Orleans in Humboldt County, on the Six Rivers National Forest. There some of the facilities of the Orleans Ranger Station were made available to project personnel and a field laboratory was established. Cooperation from several other sources has helped to facilitate progress in the research. The Department of Entomology and Parasitology, University of California, made available insectary and cold room facilities at Berkeley for certain phases of the work. R. E. Stevens and C. J. DeMars assisted in gathering the cone samples. The insects reared from the cone samples were identified by specialists in the Insect Identification and Parasite Introduction Laboratories, Entomology Research Division, Agricultural Research Service, U. S. Department of Agriculture, Washington, D. C.

1957 REARING EXPERIMENT

Small-scale rearing experiments were conducted primarily to obtain specimens of the insects damaging the cones along with the associated parasites and predators. Because most of the damage is done by larvae which are difficult to identify, it was necessary to rear out adult specimens. The possibility of obtaining data on the extent of parasitism was also a consideration in this work.

Materials and Methods

Samples of cones from the 1957 cone crop were collected during late August and early September from eleven Douglas-fir trees. The crop was poor and heavily infested and the individual samples were small. Thus the samples from two pairs of trees were combined into two larger samples to make a total of 9 samples. Each of the nine

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2/ Keen, F. P. 1958. Cone and seed insects of western forest trees. U. S. Dept. Agr. Tech. Bul. 1169, 168 pp., illus.

3/ Stevens, R. E. 1959. Surveys of Douglas-fir cone and seed insect damage in northwestern California. Jour. Forestry 57(12): 897-899, illus.

batches of cones was divided into two equal parts. Half of each sample was kept in the laboratory while the other half was placed in the outdoor insectary at the Oxford tract, University of California. Those samples which were kept in the laboratory were placed in 1-gallon size liquid food containers which were covered with aluminum foil to reduce the evaporation rate. The cartons used in the insectary had no protective covering.

As insects emerged from the cone samples they were collected and preserved in 70 percent alcohol excepting the Lepidoptera, which were mounted on insect pins. When the experiment was terminated in June 1958, the various species were counted and specimens were sent to specialists for identification.

Results

The kinds and numbers of insects obtained from the rearing experiment were tabulated and compared with the insect populations found by dissecting cones from the same trees. The data (table 1) show large differences between expected and obtained values. Larvae of Dioryctria abietella and Contarinia sp., and pupae of Barbara colfaxiana were present in numbers far in excess of the numbers of adults produced. Fair numbers of Megastigmus spermotrophus emerged from cones held in the insectary, but their numbers were still far less than expected. Table 2 contains a complete list of the insect species reared.

It is fairly obvious that the conditions under which the rearings were conducted were not suitable for the insects involved. If the parasites or predators present in the cones had destroyed the insect population, a considerable number of adult parasites should have emerged. The numbers of parasites and predators produced were considerably lower than expected. Most of the species involved in the rearings are reported to have a portion of the population which does not transform to the adult stage after the first winter but holds over for one or more years. The individuals which failed to transform in this instance were later found to be dead rather than in a state of extended diapause.

It is most probable that these insects have a winter diapause which was not broken under the environmental conditions prevailing in Berkeley and the insects died because of the continued unfavorable conditions.

Table 1.--Insects reared from 713 Douglas-fir cones of the 1957 crop

Insect species	Expected	Obtained
DESTRUCTIVE SPECIES		
Barbara colfaxiana	69	1
Dioryctria abietella	85	1
Megastigmus spermotrophus	486+	35
Midges	2,800+	33
Other	0	8
PARASITES AND PREDATORS		
Chalcids	600+	555
Braconids	(1/)	9
Ichneumonids	(1/)	8
Clerids	178	16

1/ No estimate was made of the numbers expected.

Table 2.--Insects reared from Douglas-fir cones of the 1957 cone crop

Species known or suspected to be destructive to cones and seeds of Douglas-fir:

Barbara colfaxiana (Kearf.)
Dioryctria abietella (D. & S.)
Holcocera augusti Heinrich
Megastigmus spermotrophus Wachtl
Contarinia sp. nr. Oregonensis
Rubsaamenia keeni Foot

Predators and parasites:

Enoclerus humeralis (Schffr.)
Apanteles sp.
Calliephialtes comstockii (Cress.)
Glypta sp.
Elachertus proteoratis (How.)
Eupelmus brevicauda (Crawf.)
Dibraches cavus (Walk.)
Torymus sp.
Tetrastichus sp.
Amblymerus sp.
Platygaster sp.

DIAPAUSE EXPERIMENT, MEGASTIGMUS SPERMOTROPHUS

N. W. Hussey has reported that in Scotland, Megastigmus spermotrophus Wachtl has a winter diapause which can be broken by cold treatment. 4/ It was of interest to determine if the insects in California have a similar diapause.

Materials and Methods

During the winter of 1957-58, an experimental attempt was made to break the diapause of Megastigmus larvae and induce them to complete their development more quickly than normal.

Three small samples of Douglas-fir seed from Bluff Creek and Etna Summit, which were known to be infested by larvae of Megastigmus spermotrophus, were used in the experiment. The seeds were kept in half-pint liquid food containers. Two of the seed samples were kept in a refrigerator at 41°F. for 42 days. The remaining sample was kept at room temperature. At the end of the cold treatment all the samples were kept together at room temperature. When the adult insects emerged they were preserved in alcohol. The number of individuals of each sex emerging each day was recorded. Six months after the emergence of the last adults, all of the seeds were broken open and examined. The number of larvae and adults remaining in the seeds and the number of sound and hollow seeds in each sample were recorded.

Results

Adult chalcids began emerging from the seeds 13 days after the end of the cold treatment. Emergence continued for 16 days thereafter. Nearly all of the males appeared before the first females. (See table 3 for detailed data.) One female specimen emerged from the untreated sample 70 days after the end of the cold treatment.

When the seeds were opened, the sample from Etna Summit, which had produced 13 wasps was found to contain 8 additional adults trapped in the seeds and 4 larvae. The sample from Bluff Creek, which had yielded 30 normal adults, still held 19 trapped adults and 8 larvae. The check sample, which contained seeds from both locations from which one adult had emerged, was found to contain 43 larvae.

The results of this experiment indicate that mature larvae of Megastigmus spermotrophus have an obligate winter diapause which

4/ Hussey, N. W. 1955. The life histories of Megastigmus spermotrophus Wachtl (Hymenoptera:Chalcidoidea) and its principal parasite, with descriptions of the developmental stages. Trans. Royal Ent. Soc. London 106(2): 133-151, illus.

can be broken by a cold treatment of 42 days at 4°F. These results suggest that seeds infested with Megastigmus larvae could be stored under refrigeration and used to provide Megastigmus adults for insecticide testing in the laboratory at times when they would be otherwise unavailable. These results also reveal that the pupal stage of M. spermotrophus lasts less than 13 days at room temperature.

The larvae which failed to pupate after the cold treatment probably represent the portion of the population which has an extended diapause, and does not transform to the adult stage until two winters have passed. It would be interesting and perhaps profitable to investigate the factors which control this phenomenon.

1958 REARING EXPERIMENT

The scant success of the 1957 rearings indicated that more elaborate methods were required. Adult specimens of the insects damaging the cones were still needed and information on the extent of parasitism still required. Widely varied treatments were used in the hope that at least one set of conditions would produce a collection of insects which approximated the population composition found in the cones by dissections.

Materials and Methods

Samples of infested Douglas-fir cones were obtained at four locations in northwestern California. Each of the four cone samples was divided into eight sub-samples. One sub-sample from each set was dissected to obtain an estimate of the insect population. A second sub-sample was held in the office at 75° F. as an untreated check. The remaining 6 sub-samples were placed in 1/2-pint liquid food containers under the following sets of conditions. One of the sub-samples from each of the four collection localities was kept under each set of conditions. The conditions were: dry at 36°F., 22°F., 0°F., and wet at 36°F., 22°F., 0°F. At the end of the six weeks of cold treatment the cone samples were returned to the laboratory and kept in gallon liquid food containers. As insects emerged from the cones they were collected and preserved in alcohol.

Results

The numbers of insects emerging from the cones were far smaller than the numbers predicted on the basis of population data obtained by cone dissections. Because emergence was uniformly poor in the samples from all four collecting localities and the samples were of equal size, the data from all of the samples were combined. The combined data are presented in table 4. This table shows that a few insects emerged from cones held at 36°F. and 22°F. in the wet treatments and at 36°F. in the dry treatments; but that none emerged in any of the other treatments.

Table 3.--Results of experimental rearings of *Megastigmus spermotrophus* from the 1957 Douglas-fir seed crop

Treatment	Source	Seeds: Number of seeds	Seeds: Sound	Seeds: Hollow	Seeds: Infested	Insects: Adults Emerged	Insects: Adults Trapped	Insects: Remaining larvae
42 days at 41°F.	Etna Summit	111	22	64	25	13	8	4
42 days at 41°F.	Bluff Creek	108	0	51	57	30	19	8
42 days at room temp.	Mixed locations	261	38	179	44	1	0	43

			Jan.												Feb.				
			1/3	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5
42 days 41°F.	Etna Summit	♂	-	-	-	-	1	-	-	-	-	2	-	-	-	-	-	-	-	-
		♀	-	-	-	-	-	-	-	-	-	1	-	1	4	3	-	-	1	-
42 days 41°F.	Bluff Creek	♂	1	-	-	-	1	-	-	-	4	3	2	-	-	-	-	-	-	-
		♀	-	-	-	-	-	-	-	-	-	-	3	2	5	3	3	-	-	3
42 days at room temp.	Mixed locations	♂	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		♀	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1/ The cold treatment was terminated on Jan 3. The first adults emerged on Jan. 20.

Obviously none of the treatments used are at all effective in breaking the winter diapause of Douglas-fir cone and seed insects. The complete lack of emergence of any insects from the cones held for six weeks at 0°F. might be taken to indicate that prolonged exposure to very low temperatures is fatal to cone and seed insects. This is not surprising since these insects normally are found in areas where long periods of very cold weather do not occur.

Table 4.--Expected and actual numbers of insects reared under various conditions from equal numbers of Douglas-fir cones of the 1958 cone crop

Rearing conditions	Destructive species								Beneficial species	
	B. colfaxiana		*D. abietella*		*M. sembrophus*		Midges		Parasites	Predators
	Expected	Actual	Expected	Actual	Expected	Actual	Expected	Actual	Actual	Actual
WET										
36°	55	0	(1/)	1	20	3	1,100+	18	14	0
22°	55	0	(1/)	--	20	--	1,100+	--	16	0
0°	55	0	(1/)	--	20	--	1,100+	--	0	0
DRY										
75°	55	0	(1/)	--	20	--	1,100+	--	0	0
36°	55	0	(1/)	--	20	1	1,100+	2	2	0
22°	55	0	(1/)	--	20	--	1,100+	--	0	0
0°	55	0	(1/)	--	20	--	1,100+	--	0	0

1/ *D. abietella* was present in very small numbers in the cone samples used.

OTHER REARING EXPERIMENTS

Materials and Methods

Two small-scale rearing experiments, having the same objectives as the more elaborate ones, were conducted using larvae of Megastigmus spermotrophus and Contarinia sp. In the first of these, 18 samples of Douglas-fir seed infested by larvae of M. spermotrophus were held in a refrigerator at 36°F. for six weeks. Comparable check samples were kept in the laboratory. A sub-sample of 200 seeds from each seed lot was dissected to determine the percent infested. In the second experiment, larvae of Contarinia sp. were induced to leave their galls in Douglas-fir cone scales by soaking the cones in water. The larvae were placed in wet sand in 1/2-pint liquid food containers and held at 36°F. for 6 weeks.

Results

No adult insects were produced in either of these experiments. This seems most peculiar in view of the results obtained in a similar experiment in 1957.

CONE-BAGGING EXPERIMENT, 1958

Information on the seasonal history of the cone and seed insects is of prime importance in the solution of the damage problems. The period in which the insects attack the cones is extremely important in this case because it is the only time when these insects are exposed and vulnerable to insecticidal control measures. The primary objective of the experiment described here was to obtain data on the attack period of the insects. The biological observations made in conjunction with the cone bagging were intended to support and help explain the results obtained.

Materials and Methods

During the period from April 11 to 19, cone-bearing Douglas-fir trees were selected at four locations between 1,000- and 2,500-feet elevation in the Orleans District of the Six Rivers National Forest. Later in the summer additional trees were selected at two locations between 5,000 and 6,000 feet. Cone-bearing branches were covered with bags of 32-mesh lumite screening which were tied securely over the ends of the branches. The screen bags were 9 inches wide and 18 inches long. The mesh was fine enough to exclude all insects known to attack Douglas-fir cones and seeds. Branches bearing at least three and up to 8 cones were bagged. As shown in table 5, there were two cone-bearing trees at each location. The number of cones bagged on each tree is also shown in table 5.

Table 5.--Survival of bagged Douglas-fir cones, cone bagging experiment 1958

Location and elevation	Tree number	Bagging Dates: Apr.	June	July	Cones: Bagged	Survived
					Number	
LOW ELEVATION						
Bluff Creek	1	15	--	--	14	0
Bluff Creek	2	16	--	--	37	11
Coopers Ranch	1	19	--	--	16	15
Coopers Ranch	--	--	--	2	13	13
Coopers Ranch	2	19	--	--	26	4
Leary Creek	1	14	--	--	38	35
Leary Creek	2	14	--	--	45	4
Schnable Place	1	11	--	--	8	8
Schnable Place	2	11	--	--	8	3
Sub-total					205	93
HIGH ELEVATION						
Box Camp	1	--	18	--	39	38
Box Camp	2	--	18	--	23	22
Grouse Mt.	1	--	19	--	25	25
Grouse Mt.	--	--	--	21	22	22
Grouse Mt.	2	--	19	--	27	27
Grouse Mt.	--	--	--	21	15	15
Sub-total					151	149
Grand total					356	242

At the lower elevation, cones were bagged between April 11 and 19, and again on July 2. At the higher elevation, cones were bagged at two locations on June 18 and 19 and again on July 21. On each occasion, when bags were placed over cone-bearing branches, samples of cones were taken from other branches on the same tree. The usual size of sample was 25 cones, but in some instances fewer cones were taken in order to leave cones for other phases of the project. The samples of immature cones were preserved in 70 percent alcohol and later examined in the laboratory. The length of the cone, from the bud scales on the petiole to the distal end of the bracts, was measured in millimeters. The cones were examined under a large magnifying glass and insect eggs and larvae recorded when present.

When the cones matured in the fall they were harvested and stored in 1-gallon size cardboard containers, to be examined in the laboratory during the winter.

To examine the mature cones, the basal end of each was cut off with a sharp knife. The cone scales were broken off one at a time and inspected for the presence of insects or insect damage. The number and kind of insects found in each case were recorded along with the number of seeds destroyed. The seeds from each sample which escaped destruction by lepidopterous larvae and cone midges were cleaned and weighed. The total seed yield in grams per cone sample was determined and reduced to average seed yield per cone for purposes of comparison. A sub-sample of 200 seeds was taken from each sample seed lot and each seed was broken in half to determine the condition of the endosperm. In some instances, fewer than 200 seeds were obtained from a cone sample, in which case all of the seeds in the sample were broken. The seeds were classified as sound, hollow, or infested by Megastigmus larvae.

In the course of the summer approximately 800 cones were dissected. The insects from each cone sample have been preserved in 70 percent alcohol and will be used in later investigations to determine the number and timing of instars and the rate and time of parasite attack.

Results

There are two general types of results: those pertaining to observations of the life history and habits of the four species of insects found injuring cones and seed, and those pertaining to the role of each insect and the nature and extent of its damage.

Life History and Habits

The eggs of Barbara colfaxiana were already present on the first cones collected on April 11. From this we conclude that B. colfaxiana begins oviposition as soon as the cone buds open. The first pupae were found on June 26 indicating fairly rapid larval development. Data on the time and frequency of occurrence of the various developmental stages were obtained as a result of cone dissections. These data are presented in composite form in figure 1.

Where comparable data were obtained, larval mortality was quite light. Successive cone samples obtained from the same tree (Cooper's Ranch #1) on June 8, July 2, and at cone maturity in late August, had respectively 2.72, 2.61, and 2.16 Barbara larvae and pupae per cone, indicating a larval mortality of about 20 percent.

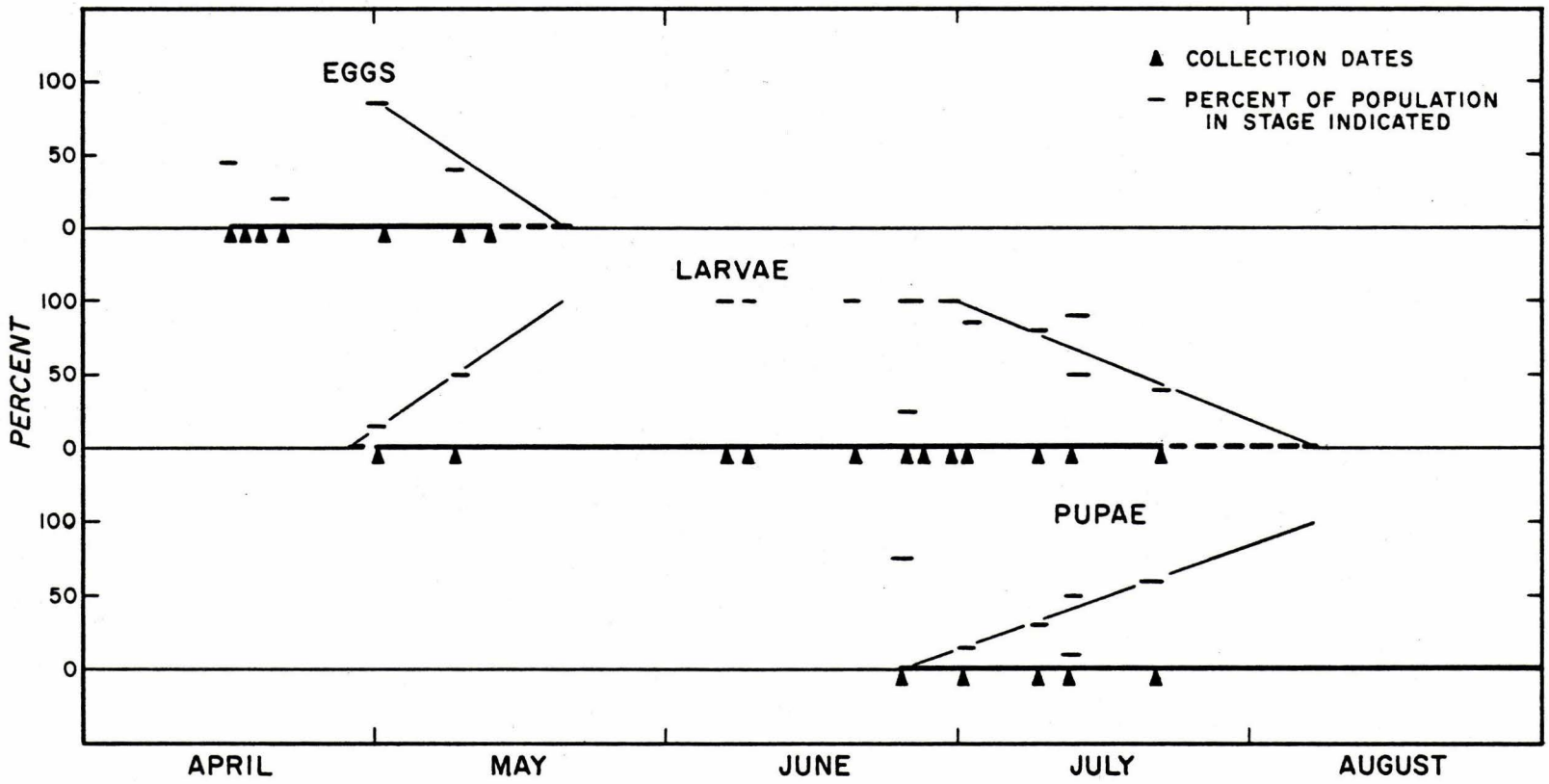

Figure 1.--Seasonal history of Barbara colfaxiana

The principal mortality agents found were a braconid parasite, Apanteles petrovae Wally 4/ and an undetermined species of larvaevorid fly. 5/ The numbers of cocoons of Apanteles found in samples of unbagged cones were counted along with the surviving larvae to obtain an estimate of the amount of mortality caused by this parasite. This parasite was present at all of the low elevation study areas and caused an estimated mortality ranging from 1.8 to 22 percent in the various samples. It was not possible to estimate the numbers of larvaevorids present on any comparable basis. However, one cone sample which contained 28 Barbara larvae yielded 4 mature larvae of the larvaevorid fly. A. petrovae emerges from the Barbara larvae as it nears maturity and proceeds to consume all except the head capsule. The Apanteles larva then spins a white cocoon about the size and shape of a grain of rice. The cocoon remains inside the cone and can be recognized long after the parasite emerges.

The larva of the larvaevorid fly consumes the entire interior of its host larva. Upon maturity it emerges from the host larva, leaving only an empty skin and leaves the cone to pupate.

The eggs of cone midges, Contarinia sp., were found at an average density of 54 eggs per cone in samples collected from April 14 to 19. They are spindle-shaped, pale cream in color, and deposited in clusters on and near the developing ovules between the cone scales when the latter are open to admit pollen. After the eggs hatched, the larvae, which are also pale green, but practically transparent, were found in the tissues of the cone scales by careful dissections under high magnification. By mid-July the midge larvae were more readily seen and a gall became noticeable in the cone tissue around each larva.

Oviposition by Megastigmus spermotrophus was not observed. The larvae of this seed chalcid were first detected on June 26 and could be readily found in the developing seeds by mid-July.

Oviposition by Dioryctria abietella was not observed. The larvae of this insect, which never became very abundant, did not appear until July.

Damage

The data obtained by examinations of the bagged cones and the corresponding check samples of unbagged cones are presented in tables 5 through 15. Table 5 shows the dates on which cones were

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4/ Determined by C. F. W. Muesebeck, Insect Identification and Parasite Introduction Laboratories, Entomology Research Division, Agricultural Research Service, U. S. Dept. of Agriculture.

5/ Identification by T. W. Koerber. The specimens were destroyed in transit to Washington. Therefore no more authorative determination is available.

bagged on two trees at each of six locations, all of which are in Humboldt County in the vicinity of Orleans. Bluff Creek, Cooper's Ranch, Leary Creek and Schnable Place are locations at elevations of 1,000 to 2,500 feet. The Box Camp and Grouse Mountain locations are between 5,000 and 6,000 feet elevation. The table also shows the number bagged on each tree, the number which died and survived on each tree. Table 6 shows the percent of the surviving cones infested by each of the insects and compares these data with those determined for the unbagged cones on the same tree.

It will be noted that only 93 of the 205 cones bagged at the low-elevation locations, mostly in April, survived, while 149 of 151 cones bagged at high-elevation sites in June and July survived. Frost and nutrient deficiencies have been suggested as possible causes for death of the cones that died. Most of the dead cones showed little or no insect damage. The death of the cones is not considered to be an effect of the bagging operation since the death rate among unbagged cones was as high as 85 percent in some samples examined. Most of the dead cones were 30 to 40 millimeters long, indicating that they died when only 3 to 4 weeks old.

In table 6 it is of interest to note that on three of four trees on which cones were bagged between April 14 and April 19, approximately half as many bagged cones as check cones were infested by Barbara colfaxiana. One tree showed no significant difference between bagged and unbagged cones. Another tree had no Barbara larvae in bagged cones and 100 percent infestation of unbagged cones. Two trees yielded no data for lack of surviving cones.

At Box Camp, a high-elevation site, one tree showed little difference between bagged cones and check cones, while another showed about half as many bagged cones as unbagged cones infested by Barbara larvae. At Grouse Mountain the bagged cones consistently showed a much higher infestation rate than unbagged cones.

In most instances, Dioryctria abietella infestation of the cones was too low to yield consistent data. However, at the high-elevation sites, the covered cones regularly showed a higher infestation rate than the uncovered cones.

The effect of cone bagging on the percent of cones in the various samples infested by Contarinia sp. is not at all clear. Half of the bagged cone samples have a much lower percent infested by Contarinia sp. than do their corresponding check samples. In the other half of the samples the percent infested is nearly the same in the bagged cones as in the check samples. It seems peculiar that the samples fall into two classes, those in which there is a

Table 6.--Insect infestation of Douglas-fir cones, cone bagging experiment 1958

Locality and elevation	Tree number	Bagging dates: First	Bagging dates: Second	Bagged cones: Number in sample	Bagged cones: Percent infested by-- Barbara	Bagged cones: Percent infested by-- Dioryctria	Bagged cones: Percent infested by-- Contarinia	Check cones: Number in sample	Check cones: Percent infested by-- Barbara	Check cones: Percent infested by-- Dioryctria	Check cones: Percent infested by-- Contarinia
LOW ELEVATION											
Bluff Creek	1	4/15	--	0	--	--	--	0	--	--	--
Bluff Creek	2	4/16	--	11	100	18	82	25	96	4	84
Coopers Ranch	1	4/19	--	15	47	20	53	25	100	16	80
	--	--	7/2	13	100	31	31	25	100	16	80
Coopers Ranch	2	4/19	--	4	0	25	0	5	100	40	40
Leary Creek	1	4/14	--	35	43	0	100	25	96	0	100
Leary Creek	2	4/14	--	4	50	0	75	9	100	0	67
Schnable Place	1	4/11	--	8	0	0	62	9	100	0	100
Schnable Place	2	4/11	--	3	0	0	0	0	--	--	--
HIGH ELEVATION											
Box Camp	1	6/18	--	38	42	25	11	25	48	0	0
Box Camp	2	6/18	--	22	23	55	36	25	48	8	80
Grouse Mt.	1	6/19	--	25	20	84	32	25	4	16	8
	--	--	7/21	22	18	45	18	25	4	16	8
Grouse Mt.	2	6/19	--	27	11	11	52	25	8	8	40
	--	--	7/21	15	0	7	53	25	8	8	40

big difference between bagged and unbagged cones and those in which there is virtually no difference. The set of samples from Cooper's Ranch #1 is the only one which might be considered to fall between the two categories.

Table 7 is a summary of data from bagged and unbagged cones. The detail data are given in tables 11 and 12 of the Appendix. Despite the fact that table 7 represents various locations and different bagging dates, it is readily apparent that the average yield of seed per cone with only one exception was much greater within the bags. The proportion of sound seed also appears to be greater in the bagged cones; however, this is largely accounted for by the action of Megastigmus spermotrophus. If seed containing M. spermotrophus are considered as having been potentially sound, there is little difference in the proportion of sound and hollow seed between bagged and unbagged cones. The number of cones in each sample is included because of the effect of sample size on the reliability of the resulting data, and the size of the cones expressed as average length is included in tables 11 and 12 because of the probable relationship between cone size and seed yield. It should be noted that with one exception the seed yield from cones bagged in April at low elevations and June at high elevations was better than that from the corresponding unbagged cones.

The data from this bagging experiment were reorganized in an effort to determine the effect of B. colfaxiana. These data which are given in table 8, clearly show that the bags were applied too late to accomplish their purpose. In nearly all samples the bagged cones had a higher number of larvae per cone and a higher percentage of infested cones per sample than did the unbagged cones. Also shown is the fact that cones, bagged or unbagged, which were heavily infested with Barbara larvae, were smaller and had a much lower seed yield than did uninfested or lightly infested ones.

The length of the cones at the time of bagging was measured to provide an index of their development. The data on average cone length at the time of bagging were obtained from cones that were collected then and later measured. The cones which were bagged at high-elevation sites were considerably larger than those bagged at low-elevation locations in April.

The data from cones infested with B. colfaxiana were analyzed to determine the relationship between the number of pupae in a cone and the number of seed destroyed. Cones in which the damage was complicated by the presence of the work of other insects were eliminated from the sample.

Table 7.--Seed yield from Douglas-fir cones in cone bagging experiment 1958

Collection site	Bagged cones					Unbagged cones				
	Bagging dates	Sample size cones	Seed yield per cone	Sound seed	Hollow seed	Sample size cones	Seed yield per cone	Sound seed	Hollow seed	Megastigmus infested seed
			Mg.	Pct.	Pct.		Mg.	Pct.	Pct.	Pct.
LOW ELEVATION	April	80	377	50	1/ 50	111	14	13.6	41.3	45.1
	July	13	5	40	1/ 40	38	24	12.7	43.6	43.6
HIGH ELEVATION	June	112	327	47	53	2/ 199	251	36.2	62.6	1.2
	July	37	453	48	52	199	251	36.2	62.6	1.2

1/ Remaining 20 percent infested by Megastigmus.
2/ The same check samples were used for comparison with both bagging dates.

As the larvae of Barbara colfaxiana near maturity, they often damage the central axis of the Douglas-fir cone causing the distal end of the cone to die and turn yellow. The yellowing of the tips of heavily infested cones was first noted on July 8. In instances where this type of damage was prevalent and when direct feeding damage was very heavy, it was not possible to determine with any degree of certainty the number of seeds which the cone contained. In these cones the number of seeds destroyed was considered to be greater than 60, sixty seeds being a conservative estimate of the number of sound seeds a Douglas-fir cone can be expected to produce. The data, as given in table 9, show that one larva, as indicated by the presence of one pupa, destroys about one-third of the seed in a cone.

Additional facts became apparent when the data were realigned and analyzed for the effect of M. spermotrophus (table 10). Unfortunately it was possible to examine only those seeds left after the depredations of the other insects. In samples which had heavy damage from other insects, there were almost no seeds left to support the Megastigmus population. The seed yield per cone is given to indicate the size of the sample involved. Table 10 shows the actual number of seeds cut and examined for Megastigmus larvae. The significant fact here is that none of the cone samples bagged at the earlier stages of development, in April at low elevations and in June at high elevations, yielded a single Megastigmus larva. Nearly all of the check samples from the same trees were infested and some very small seed samples yielded a surprising number of Megastigmus larvae.

A similar treatment of the data for D. abietella and Contarinia sp. was not as successful. However, the data are worthy of some consideration. Since the population of Dioryctria was not nearly as high as the population of Barbara, exceeding one larva per cone in only one sample, the data are not as sound. In the samples which showed Dioryctria damage the percent of cones infested was not consistently higher in unbagged cones than in bagged cones. (Table 13, appendix.) The seed yield per cone shows no obvious correlation with the number of Dioryctria larvae in the sample. The length of cones at harvest and the quality of seed likewise show no correlation with the Dioryctria population. In table 14 of the appendix, it can be seen that the larvae of Dioryctria destroy slightly fewer seed per infested cone and per larva than do the larvae of Barbara. This might be due to high larval mortality or larvae moving from one cone to another.

The data pertaining to the cone midge, Contarinia sp., is given in appendix table 15. In most instances, more seeds were destroyed in unbagged cones than in bagged ones. However, the midges were present in a fair percentage of the cones in nearly all of the bagged samples. It will be noted that in several

Table 8.--*Barbara colfaxiana* infestations in Douglas-fir cones, cone bagging experiment 1958

Locality and elevation	Tree number	Date bagged	Length at bagging	Length at harvest	Cones infested	Larvae per cone	Seed yield per cone	Sound	Hollow
			MM.	MM.	Pct.	No.	Mg.	Pct.	Pct.
LOW ELEVATION									
Bluff Creek	1	--	29.1	(1/)	(1/)	(1/)	(1/)	(1/)	(1/)
Check									
Bluff Creek	2	4/16	28.6	55.3	100	2.55	0	--	--
Check	--	--	--	60.5	96	1.80	8	18.2	31.8
Coopers Ranch	1	4/19	24.4	90.6	47	0.47	674	60	40
	--	7/2	81.0	67.2	100	2.38	5	40	40
Check	--	--	--	72.1	100	2.12	24	12.7	43
Coopers Ranch	2	4/19	31.5	87.5	0	0.00	462	38	62
Check	--	--	--	67.0	100	1.00	42	18.2	13.6
Leary Creek	1	4/14	28.4	71.9	43	0.54	314	60	40
Check	--	--	--	56.2	96	1.28	3	6.7	60
Leary Creek	2	4/14	31.5	61.6	50	0.50	236	46	54
Check	--	--	--	52.2	100	1.22	12	13.4	60
Schnable Place	1	4/11	23.5	86.9	0	0.00	665	80	20
Check	--	--	--	66.1	100	2.66	0	--	--
Schnable Place	2	4/11	--	78.3	0	0.00	393	0.5	99.5
Check	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)
HIGH ELEVATION									
Box Camp	1	6/18	51.1	65.0	42	0.50	358	64.5	35.5
Check	--	--	--	62.6	48	0.56	129	38	60
Box Camp	2	6/18	59.1	66.0	23	0.36	166	37	63
Check	--	--	--	60.0	48	0.60	125	37	62
Grouse Mt.	1	6/19	41.8	70.0	20	0.20	426	68	32
	--	7/21	93.3	79.3	18	0.18	553	76.5	23
Check	--	--	--	68.9	4	0.04	482	51	48
Grouse Mt.	2	6/19	41.4	68.0	11	0.11	329	19	81
	--	7/21	76.9	70.6	0	0.00	306	19	78
Check	--	--	--	70.2	8	0.08	307	18	79.5

1/ No sample.
2/ No check.

Table 9.--Seeds destroyed by larvae of Barbara colfaxiana in Douglas-fir cones of the 1958 cone crop

Seeds destroyed	Frequency at infestation level of-- 1 per cone	2 per cone	3 per cone
0 - 5	3	0	0
6 -10	14	0	0
11 -15	18	0	0
16 -20	38	4	0
21 -25	16	5	0
26 -30	8	13	0
31 -35	3	5	3
36 -40	5	11	3
41 -45	1	8	2
46 -50	0	3	3
51 -55	0	3	2
55 -60	1	0	2
> 60	1	19	10

samples no data are given for the number of seeds destroyed per infested cone. In these samples virtually all of the seeds were destroyed by other insects leaving few or no seeds for Contarinia. Furthermore, in the samples for which Contarinia damage figures were given, feeding by Barbara colfaxiana probably destroyed many seeds which would otherwise have been credited to Contarinia.

DISCUSSION AND CONCLUSIONS

There are a number of serious deficiencies in the data just presented which cast doubt upon their adequacy. Nevertheless, the data are useful as a first approximation of the desired information and are also useful in so far as they indicate what steps must be taken to obtain more reliable information. However, it would be extremely rash to make control decisions based on these data.

The most apparent deficiency is the size of the cone samples. Nearly a third of the bagged cones were lost to non-insect causes. The check samples also suffered serious reduction from the same unknown causes. As a result some samples were completely lost and others were reduced to the point where their reliability was seriously impaired.

Another serious deficiency developed because the insect attack started sooner than was expected and insect development was faster than expected. It was originally intended that the screen

Table 10.--*Megastigmus spermotrophus* infestations in Douglas-fir cones, cone bagging experiment 1958

Locality and elevation	Tree number	Date bagged	Number of cones	Average length	Total seed	Seed per cone	Seeds cut	Sound	Hollow	Megastigmus infested
				MM.	Grams	Mg.	No.	Pct.	Pct.	Pct.
LOW ELEVATION										
Bluff Creek	2	4/16	11	55.3	0	0	0	--	--	--
Check	--	--	25	60.5	.21	8	22	18.2	31.8	50.0
Coopers Ranch	1	4/19	15	90.6	10.11	674	200	60.0	40.0	0.0
	--	7/2	13	67.2	.07	5	8	40.0	40.0	20.0
Check	--	--	38	72.1	.93	24	110	12.7	43.6	43.6
Coopers Ranch	2	4/19	4	87.5	1.85	462	183	38.0	62.0	0.0
Check	--	--	5	67.0	.21	42	22	18.2	13.6	68.2
Leary Creek	1	4/14	35	71.9	11.01	314	200	60.0	40.0	0.0
Check	--	--	25	56.2	.08	3	15	6.7	60.0	33.3
Leary Creek	2	4/14	4	61.6	.71	236	61	46.0	54.0	0.0
Check	--	--	9	52.2	.11	12	15	13.4	60.0	26.6
Schnable Place	1	4/11	8	86.9	5.32	665	200	80.0	20.0	0.0
Check	--	--	9	66.1	0	--	--	--	--	--
Schnable Place	2	4/11	3	78.3	1.18	393	152	0.5	99.5	0.0
Check	--	--	0	--	--	--	--	--	--	--
HIGH ELEVATION										
Box Camp	1	6/18	38	65.0	13.60	358	200	64.5	35.5	0.0
Check	--	--	64	62.6	12.31	192	200	38.0	60.0	2.0
Box Camp	2	6/18	22	66.0	3.44	166	200	37.0	63.0	0.0
Check	--	--	62	60.0	7.75	125	200	37.0	62.5	0.5
Grouse Mt.	1	6/19	25	70.0	10.66	426	200	68.0	32.0	0.0
	--	7/21	22	79.3	12.16	553	200	76.5	23.5	0.0
Check	--	--	48	68.9	22.15	482	200	51.5	48.5	0.0
Grouse Mt.	2	6/19	27	68.0	8.89	329	200	19.0	81.0	0.0
	--	7/21	15	70.0	4.59	306	200	19.0	78.5	2.5
Check	--	--	25	70.2	7.69	307	200	18.5	79.5	2.0

bags would be placed over the developing cones at intervals during the period when the insects attack. In this way information on the time and rate of attack would be obtained along with damage samples at various infestation levels. As it turned out, half of the attack by Barbara colfaxiana and Contarinia sp. occurred before the first cones were covered. Later, when additional cones were to have been covered, a large part of the cone crop had died and the insects in the remaining cones were so far advanced that, in most locations, further bagging of cones was impossible or unproductive. The high population of Barbara which resulted compounded the effect of the small sample size by obscuring the work of other species and further reducing the effective sample size as far as the other insects are concerned.

In spite of the deficiencies the results are of some value. On the basis of data obtained, both by examining developing cones in the spring and by covering cones with screen bags, it is certain that oviposition by Barbara colfaxiana and Contarinia sp. begins before mid-April at low elevations in northern California. Possibly as much as half of the eggs of these species are deposited by mid-April or before the cones pass the 30 mm. stage of development. This indicates that research on these insects must be started by the first of April if data on the attack period is to be obtained.

The data clearly show that the insects develop rapidly. This suggests that surveys of the insect damage to the Douglas-fir cone crop could be conducted in late July or August rather than at the time of cone maturity, as has been done.

Two parasites not previously known to attack Barbara colfaxiana were discovered. The fact that the larvae of these parasites mature in late June or early July indicates that the attack period of the parasites is probably in early May. Since these parasites transform to the adult stage shortly after emerging from the host larvae, and since these species have not been reared from Barbara pupae, they probably have alternate hosts which carry them through the winter.

Oviposition by Megastigmus spermotrophus was not observed, and no specimens were reared from bagged cones. Evidently oviposition by this species occurs after oviposition by Barbara and Contarinia, perhaps in early May.

The cone-bagging experiment yielded some interesting data on the seasonal history and damage pattern of Barbara colfaxiana. Accepted at face value the data indicate that about 25 percent of the Barbara population, which the cones would ultimately carry, was present in the egg or small larval stage in mid-April when the cones were 25-30 mm. long. About half of the cones were infested by this time. These cones carried somewhat less than

half the number of larvae which ultimately developed in the check samples.

At Grouse Mountain, the bagged cones showed higher populations of Barbara colfaxiana than unbagged cones. This might indicate that the bags protected the larvae from parasites and predators. The same thing seems to have happened to the Dioryctria population at the high-elevation sites.

When the seed yield per cone is compared with the number of larvae per cone, and when the number of seed destroyed is correlated with the number of larvae present, it is evident that a relatively small number of Barbara larvae can sharply reduce the seed yield.

This experiment produced very little information about Dioryctria abietella. This was partly due to the low population of Dioryctria and partly due to the great amount of damage done by Barbara colfaxiana. The high population of Dioryctria inside the cone bags suggest that (1) insects might have been present when the bags were put on, (2) they might have later gained entry to the bags, or (3) the mortality outside the bags might have been so high as to reduce an initially higher population to a lower level than remained inside the cone bags. In any event, D. abietella did not exhibit a decisive influence on seed yield in this experiment.

The data indicate that the oviposition period of Contarinia sp. started before the first cones were covered. The fact that some of the bagged samples have the same percent of the cones infested as the checks, while others have a much lower percent infestation suggests that Contarinia has a short oviposition period which, in some instances, had been completed and in others not. It is not possible to infer anything about the actual population of cone midges from the data on the number of seeds per cone destroyed because the actual amount of damage done by Contarinia larvae was obscured by the feeding of Barbara colfaxiana.

The one significant fact about Megastigmus spermotrophus which the experiment provided is that the attack period for this insect was after mid-April, or when the cones are beyond the 30 mm. stage of development. The figures indicating the percent destroyed by Megastigmus are not considered to be realiable because of the very small samples used.

Table 11.--Seed yield from unbagged Douglas-fir cones, cone bagging experiment 1958

Locality and elevation	Tree number	Number of cones	Average length	Total seed	Seed per cone	Seeds cut	Sound	Hollow	Megastigmus infested
			MM.	Grams	Mg.	No.	Pct.	Pct.	Pct.
LOW ELEVATION									
Bluff Creek	2	25	60.5	.21	8	22	18.2	31.8	50
Coopers Ranch	1	38	72.1	.93	24	110	12.7	43.6	43.6
Coopers Ranch	2	5	67.0	.21	42	22	18.2	13.6	68.2
Leary Creek	1	25	56.2	.08	3	15	6.7	60	33.3
Leary Creek	2	9	52.2	.11	12	15	13.4	60	26.6
Schnable Place	1	9	66.1	0	--	--	--	--	--
Schnable Place	2	(1/)	(1/)	(1/)	(1/)	(1/)	(1/)	(1/)	(1/)
HIGH ELEVATION									
Box Camp	1	64	62.6	12.31	192	200	38	60	2
Box Camp	2	62	60.0	7.75	125	200	37	62.5	0.5
Grouse Mt.	1	48	68.9	22.15	482	200	51.5	48.5	0
Grouse Mt.	2	25	70.2	7.69	307	200	18.5	79.5	2

1/ No sample.

Table 12.--Seed yield from bagged Douglas-fir cones, cone bagging experiment 1958

Locality and elevation	Tree number	Date bagged	Number of cones	Average length	Total seed	Seed per cone	Seeds cut	Sound seed	Hollow seed	Megastigmus infested seed
				MM.	Grams	Mg.	No.	Pct.	Pct.	Pct.
LOW ELEVATION										
Bluff Creek	2	4/16	11	55.3	0	--	--	--	--	--
Coopers Ranch	1	4/19	15	90.6	10.11	674	200	60	40	0
	--	7/2	13	67.2	.07	5	8	40	40	20
Coopers Ranch	2	4/19	4	87.5	1.85	462	183	38	62	0
Leary Creek	1	4/14	35	71.9	11.01	314	200	60	40	0
Leary Creek	2	4/14	4	61.6	.71	236	61	46	54	0
Schnable Place	1	4/11	8	86.9	5.32	665	200	80	20	0
Schnable Place	2	4/11	3	78.3	1.18	393	152	0.5	99.5	0
HIGH ELEVATION										
Box Camp	1	6/18	38	65.0	13.60	358	200	64.5	35.5	0
Box Camp	2	6/18	22	66.0	3.44	166	200	37	63	0
Grouse Mt.	1	6/19	25	70.0	10.66	426	200	68	32	0
	--	7/21	22	79.3	12.16	553	200	76.5	23.5	0
Grouse Mt.	2	6/19	27	68.0	8.89	329	200	19	81	0
	--	7/21	15	70.6	4.59	306	200	19	78.5	2.5

Table 13.--*Dioryctria abietella* infestations in Douglas-fir cones, cone bagging experiment 1958

Locality and elevation	Tree number	Date bagged	Length at bagging	Length at harvest	Cones infested	Larvae per cone	Seed yield per cone	Sound seed	Hollow seed
			MM.	MM.	Pct.		Mg.	Pct.	Pct.
LOW ELEVATION									
Bluff Creek	1	--	--	--	--	--	--	--	--
Check	--	--	--	--	--	--	--	--	--
Bluff Creek	2	4/16	28.6	55.3	--	--	0	--	--
Check	--	--	--	60.5	33	.11	008	18.2	31.8
Coopers Ranch	1	4/19	24.4	90.6	20	.25	674	60	40
	--	7/2	81.0	67.2	31	.31	005	40	40
Check	--	--	--	72.1	16	.12	024	12.7	43
Coopers Ranch	2	4/19	--	87.5	25	.25	462	38	62
Check	--	--	--	67.0	40	.40	042	18.2	13.6
Leary Creek	1	4/14	28.4	71.9	0	0	314	60	40
Check	--	--	--	56.2	0	0	003	6.7	60
Leary Creek	2	4/14	31.5	61.6	0	0	236	46	54
Check	--	--	--	52.2	0	0	012	13.4	60
Schnable Place	1	4/11	23.5	86.9	0	0	665	80	20
Check	--	--	--	66.1	0	0	0	--	--
Schnable Place	2	4/11	--	78.3	0	0	393	.5	99.5
Check	(1/)	(1/)	(1/)	(1/)	(1/)	(1/)	(1/)	(1/)	(1/)
HIGH ELEVATION									
Box Camp	1	6/18	51.1	65.0	18	.21	358	64.5	35.5
Check	--	--	--	62.6	0	0	129	38	60
Box Camp	2	6/18	59.1	66.0	55	.86	166	37	63
Check	--	--	--	60.0	8	.08	125	37	62
Grouse Mt.	1	6/19	41.8	70.0	84	1.36	426	68	32
	--	7/21	93.3	79.3	45	.55	553	76	23
Check	--	--	--	68.9	16	.16	482	51	48
Grouse Mt.	2	6/19	41.4	68.0	11	.07	329	19	81
	--	7/21	76.9	70.6	7	.07	306	19	78
Check	--	--	--	70.2	8	.08	307	18	79.5

1/ No check.

Table 14.--Seeds destroyed by larvae of Dioryctria abietella in Douglas-fir cones

Locality and elevation	Tree number	Cones infested	Larvae per cone	Seed per cone destroyed	Seed per infested cone destroyed	Seed per larva destroyed
		Percent				
LOW ELEVATION						
Bluff Creek	2	--	--	--	--	--
Check	--	33	.11	.5	13.0	13.0
Coopers Ranch	1	20	.25	6.2	31.0	15.5
	--	31	.31	7.1	23.0	23.0
Check	--	16	.11	2.0	12.7	17.0
Coopers Ranch	2	25	.25	8.7	35.0	35.0
Check	--	40	.40	10.3	21.5	21.5
Leary Creek	1	0	--	--	--	--
Check	--	0	--	--	--	--
Leary Creek	2	0	--	--	--	--
Check	--	0	--	--	--	--
Schnable Place	1	0	--	--	--	--
Check	--	0	--	--	--	--
Schnable Place	2	0	--	--	--	--
Check	--	--	--	--	--	--
HIGH ELEVATION						
Box Camp	1	18	.21	2.7	12.7	17.0
Check	--	0	--	--	--	--
Box Camp	2	55	.86	15.0	27.6	17.5
Check	--	8	.08	1.6	20.0	20.0
Grouse Mt.	1	84	1.36	9.1	10.8	6.7
	--	45	.55	3.4	7.6	6.3
Check	--	16	.16	.9	5.7	23.0
Grouse Mt.	2	11	.07	.8	7.3	11.0
	--	7	(1/)	.5	3.0	(1/)
Check	--	8	.08	1.1	14.0	28.0

1/ No larva found.

Table 15.--*Contarinia* sp. infestations in Douglas-fir cones, cone bagging experiment 1958

Locality and elevation	Tree number	Date bagged	Length at bagging	Seed yield per cone	Sound seed	Hollow seed	Cones infested	Seed per cone destroyed
			MM.	Mg.	Pct.	Pct.	Pct.	
LOW ELEVATION								
Bluff Creek	2	4/16	28.6	000	--	--	82	--
Check	--	--	--	8	18.2	31.8	84	10.8
Coopers Ranch	1	4/19	24.4	674	60	40	53	3.1
	--	7/2	81.0	5	40	40	31	1.1
Check	--	--	--	24	12.7	43	80	6.6
Coopers Ranch	2	4/19	--	462	38	62	0	0.0
Check	--	--	--	42	18.2	13.6	40	1.0
Leary Creek	1	4/14	28.4	314	60	40	100	8.0
Check	--	--	--	3	6.7	60	100	17.5
Leary Creek	2	4/14	31.5	236	46	54	75	--
Check	--	--	--	12	13.4	60	67	--
Schnable Place	1	4/11	23.5	665	80	20	62	--
Check	--	--	--	0	--	--	100	--
Schnable Place	2	4/11	--	393	.5	99.5	0	--
Check	--	--	--	--	--	--	--	--
HIGH ELEVATION								
Box Camp	1	6/18	51.1	358	64.5	35.5	11	.4
Check	--	--	--	129	38	60	0	0
Box Camp	2	6/18	59.1	166	37	63	36	1.0
Check	--	--	--	125	37	62	80	9.5
Grouse Mt.	1	6/19	41.8	426	68	32	32	1.2
	--	7/21	93.3	553	76	23	18	1.2
Check	--	--	--	482	51	48	8	.5
Grouse Mt.	2	6/19	41.4	329	19	81	52	1.7
	--	7/21	76.9	306	19	78	53	2.6
Check	--	--	--	307	18	79.5	40	1.1